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09/918,136	07/30/2001	Jianming Fu	AM2390.D2	3336

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EXAMINER
CANTELMO, GREGG

ART UNIT	PAPER NUMBER
1745	9

DATE MAILED: 09/20/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 09/918,136	Applicant(s) FU, JIANMING	
	Examiner Gregg Cantelmo	Art Unit 1745	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *11 June 2002* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *6-26* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☒ Claim(s) *21-26* is/are allowed.

6)☒ Claim(s) *6-16 and 18-20* is/are rejected.

7)☒ Claim(s) *17* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) *6* .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

DETAILED ACTION

Response to Amendment

1. In response to the amendment received June 11, 2002:

   a. The drawing objections have been withdrawn;

   b. The specification objection has been withdrawn;

   c. The 112 rejections have been withdrawn;

   d. The prior art rejections have been withdrawn;

   e. The obviousness-type double patenting rejections have been withdrawn.

Terminal Disclaimer

2. The terminal disclaimer filed on June 11, 2002 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of U.S. patent No. 6,290,825 has been reviewed and is accepted. The terminal disclaimer has been recorded.

3. The terminal disclaimer filed on June 11, 2002 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of U.S. Application Serial No. 09/918,135 has been reviewed and is accepted. The terminal disclaimer has been recorded.

Claim Rejections - 35 USC § 102

4. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

5. Claims 6 and 7 are rejected under 35 U.S.C. 102(b) as being anticipated by JP 63-282263 A (JP '263).

Figs. 1 and 2 disclose a method of sputtering a metal on a substrate supported on a pedestal in a system including a magnetron disposed on a side of the target opposite said pedestal and including an outer pole of one magnetic polarity and surrounding an inner pole of another magnetic polarity, wherein said outer pole extends from a center of the target to a peripheral portion of the target and has an area smaller than a similarly extending circle, said method comprising: rotating the magnetron about the center of the target to achieve full sputtering coverage of the target and capacively coupling power into the chamber at least partially by applying DC power to the target to excite the working gas into a plasma to sputter metal from the target onto the working substrate (as applied to claim 6).

The target is aluminum (translated page 4 as applied to claim 7).

Response to Arguments

6. Applicant has amended claim 6 to make it significantly broader than previously recited. In doing so, it opens the claim to new grounds of rejection.

Claim Rejections - 35 USC § 103

7. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

8. Claims 8, 9 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over JP '263 in view of U.S patent No. 5,593,551 (Lai).

The teaching of claim 6 has been discussed above and is incorporated herein.

The differences between instant claims and JP '263 are that JP '263 does not disclose using a copper target (claim 8) or titanium target (claim 9) or a barrier metal (claim 20).

It is well established in the art to sputter copper and titanium targets in a magnetron sputtering apparatus (Lai, col. 1, ll. 25-30 and col. 3, ll. 56-62). Selection of the particular target material being dependent upon the desired coating applied to the substrate. Titanium being sputtered as barrier layers in semiconductor contacts (as applied to claims 9 and 20). Copper being used as a metallization feature in semiconductor devices (as applied to claim 8).

The selection of a known material based on its suitability for its intended use supported a prima facie obviousness determination in Sinclair & Carroll Co. v. Interchemical Corp., 325 U.S. 327, 65 USPQ 297 (1945) See also In re Leshin, 227 F.2d 197, 125 USPQ 416 (CCPA 1960). MPEP § 2144.07.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of JP '263 by replacing the aluminum target material with either copper or titanium since all of these materials are known targets used in magnetron sputtering systems and the selection of the particular target material is dependent upon the manufacturing process of the substrate. The selection of a known material based on its suitability for its intended use supported a prima facie obviousness determination in Sinclair & Carroll Co. v. Interchemical Corp., 325 U.S. 327, 65 USPQ 297 (1945) See also In re Leshin, 227 F.2d 197, 125 USPQ 416 (CCPA 1960). MPEP § 2144.07.

9. Claims 10, 19 and 20 are rejected under 35 U.S.C. 103(a) as being unpatentable over JP '263 in view of JP 10-152774 A (JP '774 A).

The teaching of claim 6 has been discussed above and is incorporated herein.

The differences between instant claims and JP '263 is that JP '263 does not disclose the magnetic flux differential (claim 10) or of sputtering a barrier layer (claim 20), or using DC power sufficient to achieve an ionization density of said metal of at least 20%.

Claim 10:

JP '774 teaches of using unbalanced magnetron sputtering wherein the flux of the outer magnet arrangement is 6 times that of the inner magnet arrangement (translated paragraph [0031]).

The motivation for using unbalanced magnetron sputtering as taught by JP '774 is to confine the plasma to a smaller region and thus create a high density plasma (see Fig. 3 as applied to claim 10).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of JP '263 by using unbalanced magnetron sputtering as taught by JP '774 since it would have confined the plasma to a smaller region and thus create a high density plasma.

Claim 19:

JP '774 uses unbalanced magnetrons sputtering in conjunction with a target power of 6kW (translated paragraph [0054]) in the apparatus of Fig. 3 (no inductive coupling).

The combination of the DC power to the target as well as the unbalanced magnetron effect which focuses the plasma and creates a high density plasma in a smaller volume will provide the same ionization density. See translated paragraphs [0033] and [0034] which evidence that the sputtered metal is ionized).

The motivation is to improve the deposition by controlling the incident angle of the sputtered particles onto a substrate.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of JP '263 by using the unbalanced magnetron and DC power level of JP '774 to improve the deposition by controlling the incident angle of the sputtered particles onto a substrate.

Claim 20:

JP '774 discloses that the unbalanced magnetron sputtering can be used in forming Ti or Al alloy films (translated paragraph [0003]). The titanium being a barrier metal (as applied to claim 20).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of JP '263 by replacing the aluminum target material with either copper or titanium since all of these materials are known targets used in magnetron sputtering systems and the selection of the particular target material is dependent upon the manufacturing process of the substrate. The selection of a known material based on its suitability for its intended use supported a prima facie obviousness determination in Sinclair & Carroll Co. v. Interchemical Corp., 325 U.S. 327, 65 USPQ 297 (1945) See also In re Leshin, 227 F.2d 197, 125 USPQ 416 (CCPA 1960). MPEP § 2144.07.

10. Claim 18 is rejected under 35 U.S.C. 103(a) as being unpatentable over JP '263 in view of JP '774 and .

The teaching of claim 6 has been discussed above and is incorporated herein.

The difference between instant claim and JP '263 is that JP '263 does not disclose using a DC power no more than 18 kW normalized to a 200 mm circular substrate.

JP '774 uses unbalanced magnetrons sputtering in conjunction with a target power of 6kW (translated paragraph [0054]) in the apparatus of Fig. 3 (no inductive coupling).

These references are silent to the size of the substrate. However, a 200mm silicon substrate was widely employed in the semiconductor industry in the manufacturing of integrated circuits. One of ordinary skill would have found it obvious that the prior art used 200mm diameter substrates due to their widespread use in the industry. Application of the process to a 300mm diameter substrate would not have been cost effective since this would require significant changes in the overall size and structure of the deposition apparatus (larger vacuum chambers, larger targets, etc).

The motivation is to improve the deposition by controlling the incident angle of the sputtered particles onto a substrate.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of JP '263 by using the unbalanced magnetron and DC power level of JP '774 to improve the deposition by controlling the incident angle of the sputtered particles onto a substrate.

Response to Arguments

11. Applicant has amended claim 6 to make it significantly broader than previously recited. In doing so, it opens the claim to new grounds of rejection.

Claim Rejections - 35 USC § 103

12. Claims 11, 12 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over U.S. patent No. 5,833,817 (Tsai) in view of Musil et al., "Unbalanced Magnetrons

and new sputtering systems with enhanced plasma ionization" (hereafter referred to as Musil) and JP '774.

Tsai discloses a tungsten fill process comprising: placing a substrate 10 containing a hole formed in BPSG in a sputtering reactor including a titanium target, sputtering titanium 16 and titanium nitride 16 into the hole and thereafter filling tungsten 30 into the hole (see Fig. 3b). The Ti-TiN layer is formed by PVD techniques including magnetron sputtering (col. 3, ll. 20-25 and prior art claim 2 as applied to claim 11). The tungsten is formed by CVD (col. 1, ll. 28-37 as applied to claim 14). Tsai employs an RTA process after sputtering the barrier layer (col. 4, ll. 24-29 as applied to claim 12).

The differences between the instant claims and Tsai are that Tsai does not disclose the particulars of the magnetron arrangement or of using an unbalanced magnetron (claim 11).

Tsai appreciated the use of magnetron sputtering in depositing the barrier layers onto the substrate. Magnetron sputtering techniques result in a strong decrease in the plasma impedance and decrease of the discharge voltage and also a strong increase in the deposition rate of films on a substrate Also due to enhanced plasma confinement, magnetron sputtering can be carried out at lower pressures (see Musil page 117). Musil further discloses that unbalanced magnetrons provide improved plasma confinement (see Fig. 1c) which would have transported high ion currents to the substrates. In the unbalanced arrangement in Fig. 1c, there are two sets of magnets and outer magnet and inner magnet. The term "unbalanced magnetron sputtering" (UMS) refers in the art to magnetron sputtering wherein the flux densities in north and south poles of a

magnetron are unequal, in other words a difference between the magnetic flux of each pole exists. Selection of a differential between the individual magnetic fluxes provides the unbalanced effect shown in this figure. In employing unbalanced magnetron techniques as taught by Musil, the skilled artisan would have employed two magnetic poles as shown by Musil Fig. 1c and created a flux differential between these two magnet poles to confine the plasma to the substrate.

The motivation for using unbalanced magnetron arrays are that such configuration would have resulted in a strong decrease in the plasma impedance and decrease of the discharge voltage and also resulted in a strong increase in the deposition rate of films on a substrate. Also due to enhanced plasma confinement, magnetron sputtering could have been carried out at lower pressures. Unbalanced magnetrons would have provided improved plasma confinement, which would have transported high ion currents to the substrates.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Tsai by using unbalanced magnetron sputtering as taught in Musil since it would have resulted in a strong decrease in the plasma impedance and decrease of the discharge voltage and also resulted in a strong increase in the deposition rate of films on a substrate. Also due to enhanced plasma confinement, magnetron sputtering could have been carried out at lower pressures. Unbalanced magnetrons would have provided improved plasma confinement, which would have transported high ion currents to the substrates.

With respect to the particular differential between the poles being at least 1.5:

JP '774 teaches of using a flux differential between the outer and inner poles which is greater than 2 (as discussed above, incorporated herein).

The motivation for using unbalanced magnetron sputtering as taught by JP '774 is to confine the plasma to a smaller region and thus create a high density plasma (see Fig. 3 as applied to claim 10).

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Tsai by using unbalanced magnetron sputtering as taught by JP '774 since it would have confined the plasma to a smaller region and thus create a high density plasma.

13. Claim 13 is rejected under 35 U.S.C. 103(a) as being unpatentable over Tsai in view of Musil and JP '774 as applied to claims 11, 12 and 14 above, and further in view of U.S. patent No. 5,599,739 (Merchant).

The difference not yet discussed is not annealing between the sputtering and filling steps.

Tsai discloses using an RTA step to react the titanium layer with the silicon to form TiSi2 while also forming intimate chemical bonds with the BPSG. While this step is employed, Tsai does not state that this steps is critical to forming the multilayer structure.

The specification does not provide any unexpected results or novel benefits to the process which does not anneal the barrier layer.

While not wishing to be bound to any theory, it is believed that RTA tends to cure pinhole defects in the titanium nitride layer, thereby reducing the likelihood of volcano growth during tungsten deposition. It should be understood that annealing is an optional step (col. 3, ll. 38-53).

Thus while RTA of barrier layers tends to cure pinhole defects in the barrier layer, such a process can be an optional process and thus not required.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Tsai by not employing an annealing step since the RTA annealing step is known in the art as an optional step for curing pinhole defects.

14. Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over Tsai in view of Musil and JP '774 as applied to claims 11, 12 and 14 above, and further in view of U.S. patent No. 4,717,462 (Homma).

The difference not yet discussed is of sputter depositing the tungsten (claim 15).

As is well known, in the production of semiconductor integrated circuits, bubble memory elements and the like, a deposition method, such as vacuum evaporation, sputtering or CVD (Chemical Vapor Deposition), is employed in order to form various types of thin films. Of these methods, sputtering has an advantage in that it has the capability of forming a high -melting-point metal film and a thin film with a composition similar to that of a target and with a sufficient uniformity. Therefore, sputtering deposition is widely used for the formation of various kinds of metal or alloy films such as W, Mo or Al-Si alloy, or of an insulating film such as SiO_2, Al_2O_3 or Ta_2O_5.

Furthermore, since sputtering is advantageous in that the impurity content of the deposited film is extremely small, this method has replaced conventional vacuum evaporation for the purpose of forming a film of a metal having a relatively low melting point, such as Al (Homma, col. 1, ll. 9-27).

The motivation for sputtering tungsten is to deposit a tungsten film of higher purity and of the same composition as the target.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Tsai by sputtering the tungsten plug since it would have deposited a tungsten film of higher purity and of the same composition as the target.

15. Claim 16 is rejected under 35 U.S.C. 103(a) as being unpatentable over Tsai in view of Musil and JP '774 as applied to claims 11, 12 and 14 above, and further in view of U.S. patent No. 5,593,551 (Lai).

The difference not yet discussed is of rotating the magnetron about the back of the target.

Musil shows in Fig. 1c of a magnetron array disposed behind and about the back of the target. Musil does not show the magnetron array to be a rotating array.

The skilled artisan would have found such a modification to be well known and obvious.

In Lai, magnet means 80 may be configured to provide highly uniform erosion over nearly the entire surface 75 of sputter target assembly 70 when it is rotated.

The motivation for rotating the magnetron array is to provide uniform erosion of the target surface and thus improve the utility factor and extend the life of the target.

Therefore it would have been obvious to one of ordinary skill in the art at the time the claimed invention was made to modify the teachings of Tsai by rotating the magnetron array since it would have provided uniform erosion of the target surface and thus improved the utility factor and extended the life of the target.

Response to Arguments

16. Applicant's arguments with respect to claims 11-16 have been considered but are moot in view of the new ground(s) of rejection.

Allowable Subject Matter

17. Claims 21-26 are allowed.

18. The following is an examiner's statement of reasons for allowance: none of the prior art of record is considered to teach, suggest or render obvious the invention of claims 21-26.

The magnetron of the process is asymmetric about a center of the target. This precludes magnetrons having circular, oval or other symmetric shapes as well as net symmetry of a rotating magnetron (such as that shown in JP 62-089864. The magnetron configuration in JP '263 is oval and has symmetry.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably

accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

19. Claim 17 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

20. The following is a statement of reasons for the indication of allowable subject matter: none of the prior art of record is considered to teach, suggest or render obvious the invention of claims 17.

The magnetron of the process is asymmetric about a center of the target. This precludes magnetrons having circular, oval or other symmetric shapes as well as net symmetry of a rotating magnetron (such as that shown in JP 62-089864. The magnetron configuration in JP '263 is oval and has symmetry.

Conclusion

21. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the

shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

22. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Gregg Cantelmo whose telephone number is (703) 305-0635. The examiner can normally be reached on Monday through Thursday from 8:00 a.m. to 5:30 p.m. If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Pat Ryan, can be reached on (703) 308-2383. FAX communications should be sent to the appropriate FAX number: (703) 872-9311 for After Final Responses only; (703) 872-9310 for all other responses. FAXES received after 4 p.m. will not be processed until the following business day. Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0661.

gc

September 17, 2002

Patrick Ryan
Supervisory Patent Examiner
Technology Center 1700